STUDIES IN SILURIAN BRACHIOPODA.

I. DESCRIPTION OF A NEW GENUS AND SPECIES.

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(Plate vii; two Text-figures.)

[Read 25th June, 1941.]

Introduction.

The object of this paper is to discuss and study the variation within a species of Silurian Brachiopoda described as new, and for which a new genus is also proposed.

The specimens comprise a set of some three hundred brachiopods collected from a limestone band within the Yass Beds, near Cliftonwood, Yass River. Previously, no description nor figure has been published but the form was referred by Shearsby (1912, pp. 112, 113) to Dun's species *Meristina* (?) *australis* (Dun, 1904, p. 318). It is evident that this was a misinterpretation, as the two species have very few common characters and are now placed in different families.

Collection was restricted to a single zone, from a band of impure limestone 1–2 feet thick. Weathered specimens were picked out or sifted from the soil over an area of some 9–10 feet in the direction of dip. A large proportion of these were adult stages, with relatively few of the immature and young, so that most of the discussion deals with characters as developed in the adult.

Methods of Investigation.

Various methods were used to determine the details of internal and external characters of the shell.

The complete set of specimens was subjected to measurement of length, breadth, thickness, height (or length) of dorsal valve, length of hinge line and umbonal angle. Each of the linear measurements was correct to one-tenth of a millimetre and the angular measurement to a half-degree. The percentages of length to breadth, length of dorsal valve to length, thickness to length and length of hinge line to breadth were calculated. Graphs were plotted to show the amount of variation within the group.

The nature of the internal characters was revealed by the construction of serial sections and in the production of internal and external moulds.

A few specimens were selected for the preparation of serial sections. As far as possible average forms were used, but consideration was given to good preservation and absence of chipping in the shell. The treatment, preliminary to grinding, was essentially that of Muir-Wood (1934) for some Mesozoic brachiopods, with slight modifications.

The selected specimen was heated to red heat over a Bunsen flame for about ten to fifteen minutes, care being taken to introduce the heat gradually and so avoid splitting and flaking of the outer shell layers. Heating was always continued until the specimen appeared to have been sufficiently calcined to contrast the detail of the internal structures against the matrix. It was then allowed to cool in the air, without plunging into water, and when *completely* cold, an application of a solution of one part of amyl acetate in four parts of collodion was made. When this was dry a further coating of the solution was applied and the process was repeated until a bright pink skin was formed, completely enclosing the specimen. Usually four or five coats sufficed. When thoroughly

* This work was carried out during the tenure of a Science Research Scholarship and while the writer was part-holder of the Deas-Thomson Scholarship for Geology in the University of Sydney.

dry, the specimen was mounted in plaster of Paris on a grinding tray. The writer found it necessary to mount the specimen as soon as possible after the previous process to avoid disintegration.

Finally the grinding tray was securely attached to the calibrated grinding instrument (similar to that of Caldwell, 1935). Transverse and longitudinal sections at right angles to, and parallel to the plane of symmetry were constructed by grinding off known thicknesses of the shell. The exposed section, showing the shelly structures partly calcined and appearing white against the darkened matrix as a result of the heating process, was drawn at frequent intervals, always with any change in the internal features. A camera lucida enabled the production of enlarged diagrams.

Internal and external moulds were prepared for the examination of muscle scars, pallial markings and external ornamentation. This was accomplished by heating the specimens to redness and carefully scraping off the softened shell with a sharp needle under the binocular microscope (cf. Ulrich and Cooper, 1938).

Genus Spirinella, n. gen.

Meristina Shearsby 1912, *Rep. Aust. Ass. Adv. Sci.*, Sydney, 1911, xiii, 112–113.

non *Meristina* Hall 1867, *20th Rep. N.Y. State Cabinet.* 1867, 157, fig. (*fide* Schuchert and Le Vene, 1929).

non *Meristina* (?) Dun 1904, *Rec. Geol. Surv. N.S.W.*, vii (4), 318.

Diagnosis.—Relatively smooth Spiriferids; outline transversely semi-oval to semi-circular. Ventral interarea anacline, moderate in size, divided medially by a triangular delthyrium; cardinal margin submegathyrid. Well developed blunt teeth of the ventral valve fit into corresponding sockets of the dorsal. Apical plates inclined, divergent; median septum absent. Brachial supports in the form of two opposed spires of seven to eight volutions, directed postero-laterally, not united at any part by a jugum. Slight sulcus in ventral valve with a corresponding fold on the dorsal. Anterior commissure uniplicate but only slightly deflected by the sinus of ventral valve.

Ornamentation of only very fine radiating striae superimposed on fine concentric growth lines.

Shell substance fibrous and impunctate.

Genotype.—*Spirinella caecistriata*, n. sp., Yass Beds, Cliftonwood, near Yass, N.S.W.

Spirinella caecistriata, n. sp.

(*caecus*, obscure; *striatus*, striated.)

Meristina (?) *australis* Shearsby 1912 (*nomen nudum*), *Rep. Aust. Ass. Adv. Sci.*, Sydney, 1911, xiii, 112–113.

non *Meristina* (?) *australis* Dun 1904, *Rec. Geol. Surv. N.S.W.*, vii (4), 318.

non *Atrypoidea australis* (Dun) Mitchell and Dun 1920, Proc. Linn. Soc. N.S.W., xlv, 272.

Shell small, biconvex; outline transversely semi-oval to semi-circular; generally wider than long, length about nine-tenths of breadth. Ventral valve larger and always slightly more convex than the dorsal. Ventral umbo incurved, dorsal much smaller; umbonal angle 104°–105° (average). Cardinal margin submegathyrid; hinge line equal to about nine-tenths of greatest breadth of the shell; cardinal extremities rounded. Ventral interarea anacline, moderate, curved, medially divided by a fairly wide delthyrium. Deltidial plates disjunct, as two dorsally projecting divergent ridges on either side of the delthyrium. Apical plates well developed, inclined. Cardinalia as for genus. Median septum and jugal structures absent. Muscle and pallial markings not completely determined.

Folding of the shell restricted to a slight sulcus in the ventral valve and corresponding fold in the dorsal, producing a slightly uniplicate anterior commissure; lateral commissure not flexed. Surface ornamented by very fine radiating striae, about 15–16 per mm. (average) and hardly visible to the naked eye, superimposed on fine concentric growth lines; in the posterior portion 3–4 per mm., but 9–10 to the space of one millimetre near the anterior margin.

Shell substance fibrous and impunctate.

Holotype; specimen No. F39376, and two paratypes, Nos. F39378 and F39379, in the Australian Museum, Sydney.

Only the external features observed. Shell rather strongly biconvex; convexity of ventral valve greater than that of the dorsal. Ventral valve with a rounded umbo, incurved; umbo of dorsal valve not prominent. Ventral interarea slightly curved; features of delthyrium covered by matrix. Sulcus of ventral valve not well defined; corresponding fold on dorsal valve giving slight sinus in anterior margin (uniplicate); anterior and lateral commissures closely fitting, not crenulated, but a little distorted in the specimen.

Most of the outer lamellar layer has been removed but the portion preserved shows growth lines and faint indications of radiating striae. The presence of pallial markings as radiating ridges on the internal mould is revealed in the pedicle valve, where portion of the fibrous shelly layer has been removed.

The following table gives measurements of the holotype, and for specimens *A*, *B* and *C*, sectioned for Text-fig. 2, also the average of all specimens collected.

	Holotype	*A*	*B*	*C*	*Average*
Length in mm.	16·6	16·5	17·8	16·1	13·8
Breadth in mm.	17·5	17·2	18·5	18·9	15·8
Thickness in mm.	11·0	11·7	12·3	12·1	9·6
Length of dorsal valve in mm.	13·2	13·0	14·4	14·4	11·5
Hinge-line in mm.	15·5	—	16·1	16·1	14·1
Umbonal angle in degrees ..	104	100·5	106·5	103	104·1
Per cent. length to breadth ..	95·5	95·9	96·2	85·2	87·0
Per cent. length of d.v. to length	79·5	78·8	80·9	89·5	82·2
Per cent. hinge-line to breadth	88·6	—	87·0	84·7	89·6
Per cent. thickness to length ..	68·3	71·0	69·1	75·2	68·6

Topotype material is in the Australian Museum Collection, Nos. F38810 and F38811, and in the collection of the Geological Department, University of Sydney, No. 7556.

Horizon and locality.—Limestone band of upper portion of the Yass Beds, from the outcrop near Cliftonwood, Yass River, about three-quarters of a mile below Railway Bridge in Por. 14, opp. Por. 103, Ph. Yass, Co. King. Silurian.

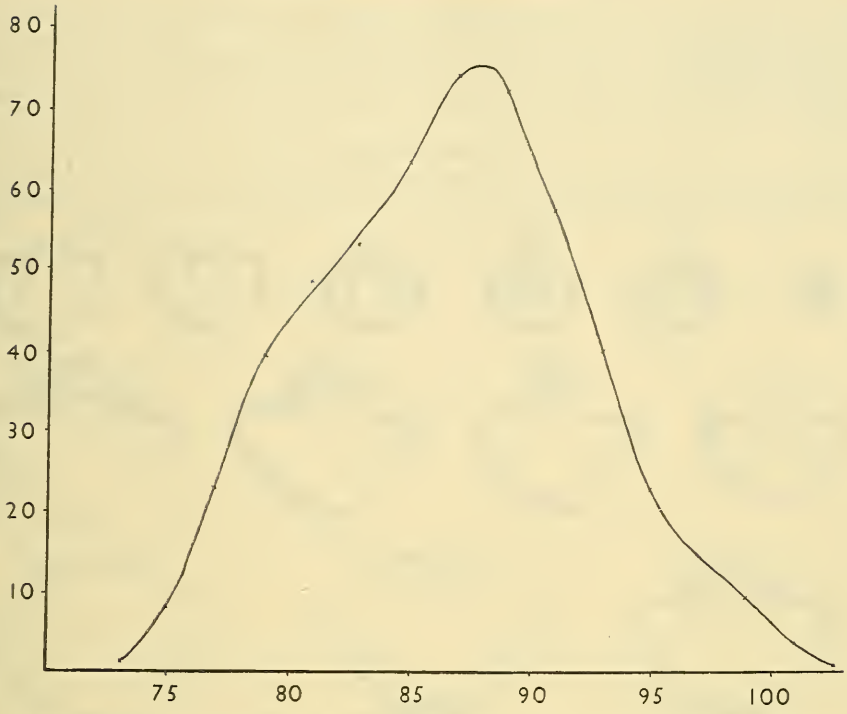
DISCUSSION.

External Characters.

Normal shells are transversely oval in outline, with the length approximately nine-tenths of the breadth and the maximum thickness occurring in the median plane, being usually rather greater than half (about three-fifths) the breadth. Graphs were plotted showing (*a*) percentage length to breadth, (*b*) percentage thickness to length, (*c*) percentage length of dorsal valve to length and (*d*) percentage length of hinge line to breadth, against the number of specimens with the respective percentages. In the graph (Text-fig. 1) the percentage length to breadth is plotted at intervals of two on the percentage scale for some 280 specimens and thus indicates the variation in the ratio of length to breadth. Since these graphs have the nature of simple curves, it is considered that a single species is present.

The maximum breadth is always attained anteriorly to the cardinal margin, at varying distances from the latter but never more than one-third of the length of the dorsal valve, in average forms being at about one-quarter of this distance (i.e., from hinge line to anterior margin). The umbones are both rounded, that of the ventral valve being incurved and much more prominent and higher than that of the dorsal. Measurements of the umbonal angle (Muir-Wood, 1935; apical angle North, 1920) give an average of 104° but a large percentage of the specimens have values from 98–112° although some are as low as 90° and others as high as 124°.

The ventral interarea (Buckman, 1919; Muir-Wood, 1935; Schuchert and Cooper, 1931, 1932; cardinal area North, 1920) anacline, of moderate size, is slightly concave, although always straight in horizontal section, and divided medially by a triangular delthyrium. In the majority of specimens the area is completely concealed by adhering matrix and thus can only be determined in section. The delthyrial angle (St. Joseph, 1935; North, 1920) varies from 45° to 60° and the delthyrium is partially closed by two deltidial plates. In none of the specimens examined was there any interarea present on the dorsal valve.



Text-fig. 1.—Curve representing the distribution of individuals according to their percentage length to breadth ratio.

Deltidial Plates.—The presence of deltidial plates (deltidium discretum Miloradovitch, 1937; deltidium George, 1932) was revealed by the transverse sections, although their position could be observed in the preparation of internal moulds. Their nature is too delicate in contrast to the hard limestone matrix in which they are embedded to permit the removal of the latter.

For the greater part of their length (i.e., equivalent to the lateral edge of the delthyrium) they are discrete, but are united just below the ventral umbo. They have the form of two thin "more or less triangular plates, but the triangles are included within the delthyrium apically, rather than cardinally, as generally occurs in the terebratuloids and rhynchonelloids. The plates project above the surface of the cardinal area at a marked angle". (George, 1932, p. 526, for *Phricodothyris.*)

In this case the angle is about 120°–135° while if extended dorsally, the two plates would converge at 60°–90°. Transverse sections 4–9 (Text-fig. 2) just at the apex of the dorsal umbo, indicate that the extent is at least half-way from the ventral interarea to the dorsal umbo, and that they are continuous with the apical lamellae, but are inclined at a blunt angle to these latter.

Folding and Ornamentation.—The median ventral sulcus and corresponding dorsal fold are only poorly defined even in the specimens with greatest depression and elevation in the respective valves, although they are developed to some extent in all specimens examined, while a certain amount of deflection dorsally (sinus) occurs in the anterior commissure (uniplicate) as well as a corresponding deflection in the growth lines as they cross the sulcus.

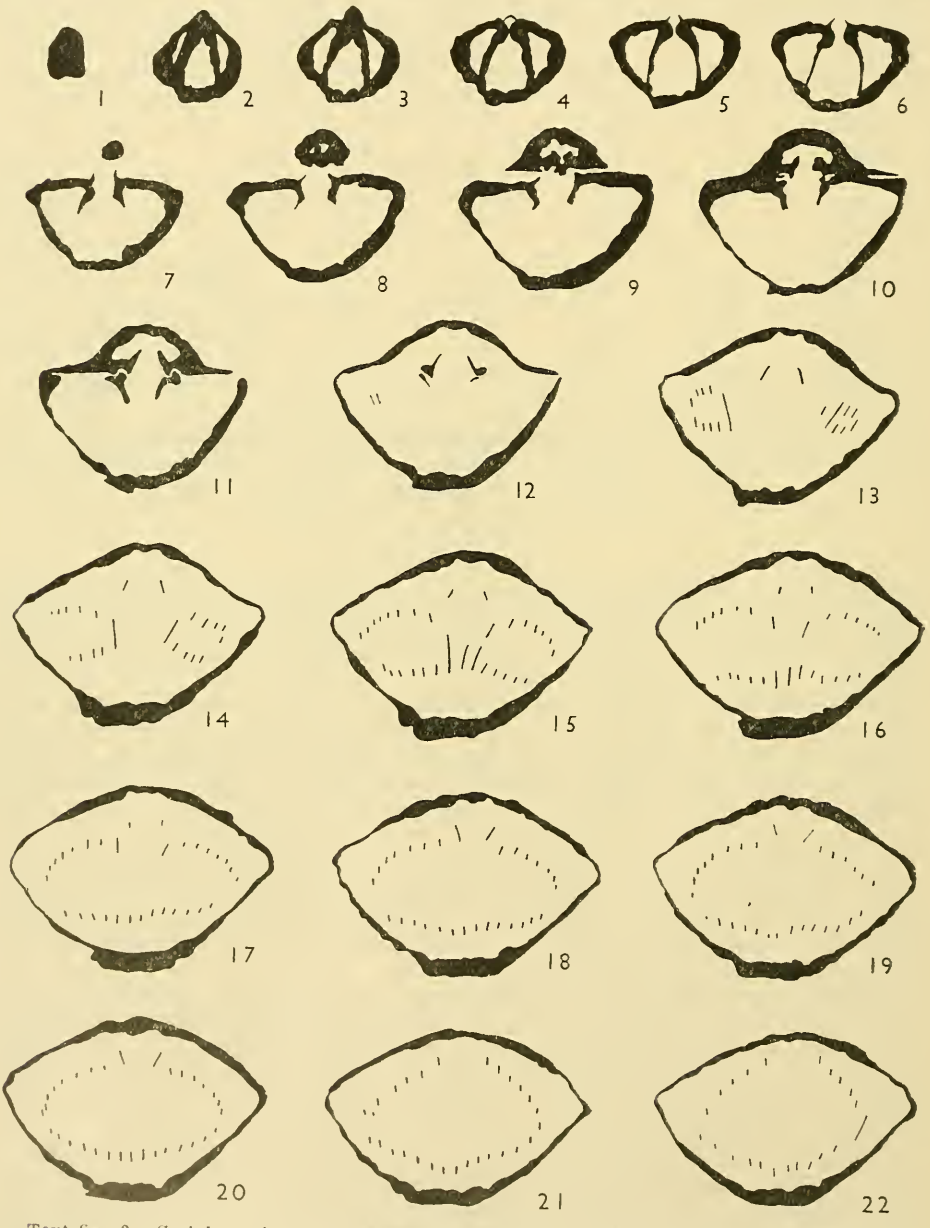
Ornamentation is only slightly impressed on the surface of the shell substance but is similar over both valves except for a concentration of growth lines toward the anterior margin. Radiating striae are very fine, not generally visible to the naked eye nor on any untreated specimens. In practically all cases it was necessary to remove the adhering shelly material from an external mould, and this was only made possible after the application of heat before gently chipping the shell with a sharp needle. The arrange-

ment of the striae was fairly uniform, from fourteen to eighteen occurring within the space of a millimetre.

A large proportion of the shells were sufficiently well preserved to exhibit concentrically developed growth lines which also were not deeply marked on the surface of the shell.

Internal Characters.

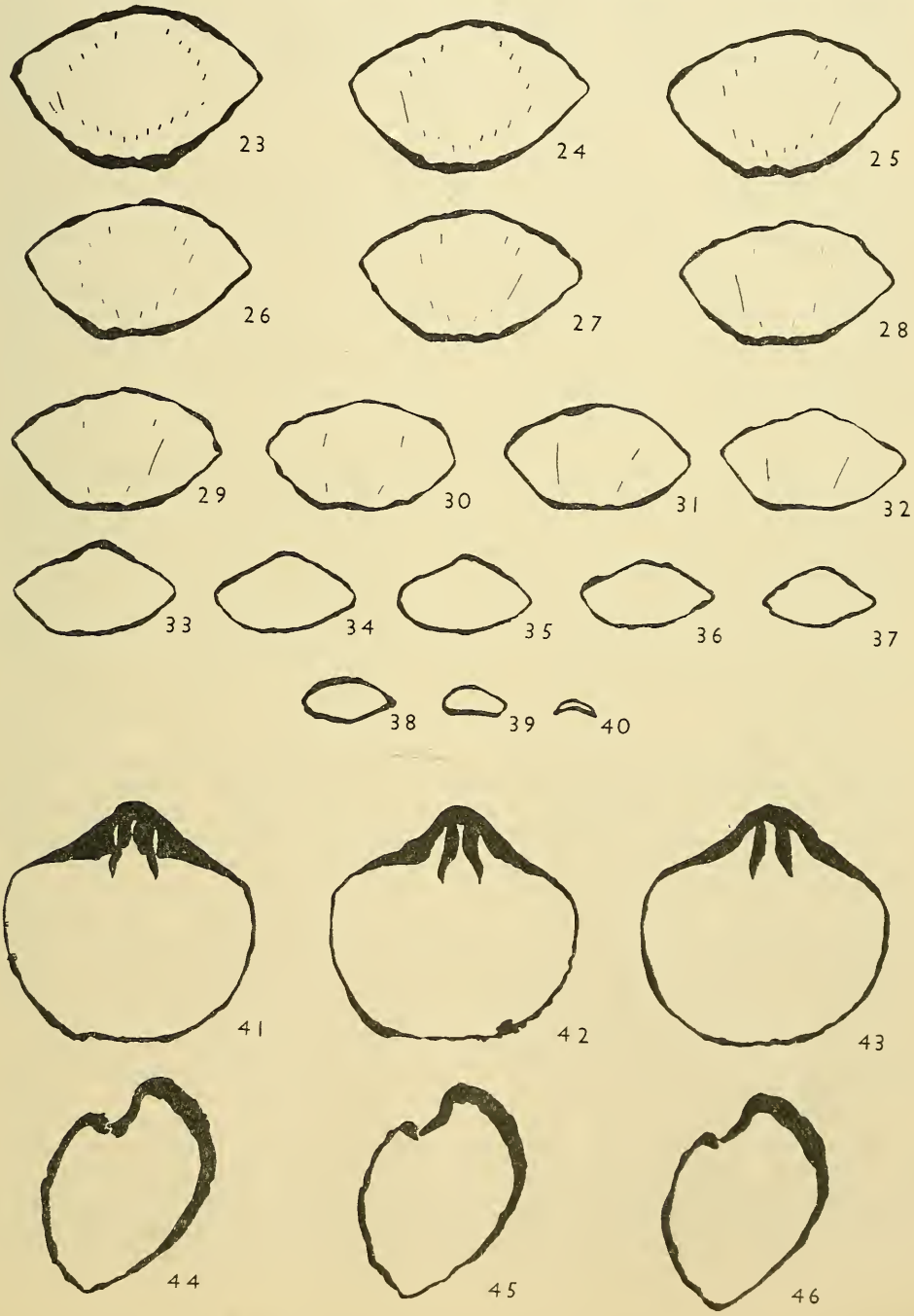
Articulation.—Articulation of the two valves is effected by the interlocking of a pair of blunt hammer-head shaped teeth in the ventral valve situated at the dorso-



Text-fig. 2.—Serial sections of *Spirinella caecistriata*, n. sp. Sections 1-40, Specimen *A*, perpendicular to length at 0·4 mm. intervals and drawn with the dorsal valve above, ventral valve below. Sections 41-43, Specimen *B*, perpendicular to thickness at 0·2 mm. intervals. Sections 44-46, Specimen *C*, perpendicular to breadth (hinge-line) at 0·4 mm. intervals. All × 2.

lateral corners of the delthyrium with a corresponding pair of dental sockets lying outside the crural bases in the dorsal valve. The articulatory processes, although well developed, are not specialized; no cardinal process is present, while indications of secondary articulatory processes adjacent to the tooth and socket union are observed in transverse sections.

Ventral Valve.—The umbonal region of the ventral valve is divided into three cavities, a central or delthyrial cavity (Schuchert and Cooper, 1931, 1932; Miloradovitch, 1937) and two lateral umbonal cavities, by two well developed apical plates (George



1927, 1932; dental plates or dental lamellae of most authors; lamellae apicales Frederiks, 1927; delthyrial supporting plates North, 1920 and Thomas, 1910). There is little secondary thickening in the region of the apical plates, so that the cavities extend right to the umbo. On their dorsal (cardinal) side the apical plates extend from the umbo along the margins of the delthyrium to the teeth, and ventrally about one-fifth of the distance from umbo to anterior commissure along the floor of the valve. They are curved processes, inclined towards one another posteriorly, with a concave anterior margin and are continuous cardinally with the deltidial plates. Lines of growth, indicating addition of shelly material along their anterior margin and having a curved contour, can be seen when the specimens have been broken along one of these apical plates. No median septum is present. Thus the apical apparatus (apical plates and median septum) corresponds in development to the Cardinalis group (Frederiks, 1926 and 1927) characterizing the subfamily Munellinae.

Dorsal Valve.—In the umbonal region of the dorsal valve a medially divided hinge plate supports the dental sockets which lie outside the crural bases, and behind this is a small umbonal cavity. The spiralia are attached to the hinge plate through the crural bases, which separate from the latter and as descending lamellae continue more or less parallel to the inner surface of the dorsal valve but slightly divergent from one another. Seven to eight volutions of a ribbon-like coil are observed in transverse sections 12–32 (Text-fig. 2), showing that the spiralia are symmetrically arranged in the thickness and breadth directions and more or less parallel to the transverse outline of the shell. The spires are dorso-laterally directed and occupy about two-thirds of the interior from the hinge line to the anterior commissure. In none of the sections prepared, nor in any intermediate stage of their production, was there any indication of the union of the descending lamellae by a jugum or jugal processes.

Musculature.—The outline and nature of the muscle scars cannot be determined from the prepared internal moulds, only their position and extent could be distinguished in the two valves. In the *ventral valve* the area of muscular attachment is situated posteriorly just below the beak, and lying between the apical plates, with an approximately equivalent extent anteriorly to these latter. This area could not be differentiated into adductor and diductor scars except that there were indications of long narrow central adductors bounded by more extensive diductors.

In the *dorsal valve* the adductor scars are posteriorly situated, just anterior to the beak and are more or less rounded in outline. The point of attachment of the diductors in this valve was not indicated but probably was posterior in position between the crural bases.

Pallial Markings.—In describing *Martinia glabra* (Martin), George (1927, p. 113) observed radially arranged ridges anterior to the muscle scars on internal moulds of the ventral valve and "in the median plane of all forms there is a well-marked ridge which extends from the umbonal region to the anterior margin". These he takes as vascular markings. Corresponding to these in *Spirinella caecistriata*, internal moulds of the ventral valve usually reveal seven radiating ridges, equivalent to depressions in the shell, with a fairly constant arrangement. A central ridge extends from the umbonal region but fades out before reaching the anterior commissure. On either side is another, adjacent to the central edge of the apical lamellae, while beyond each is a further pair a little closer to one another than the central three. These two lateral pairs do not extend quite as far towards the umbo, and also fade out before reaching the anterior commissure. None of the ridges bifurcate.

No corresponding structures were seen on any internal moulds of the dorsal valve, the surface of which is quite smooth so that pallial markings are apparently absent (cf. George, 1927, p. 113).

Shell Structure.—The shell wall is usually thin, especially in the anterior region, as it is only in the posterior portion of both valves that any thickening occurs. This is best developed at the muscle attachments, along the apical plates and other internal structures meeting the floor of the valves. In this region the shell often attains a thickness of 0·75 mm., while the outer layer bearing the ornamentation is usually absent. The nature of the shelly material of the internal structures is similar to that of the

outer shell wall (i.e., fibrous and impunctate). A longitudinal section through the plane of symmetry of the valves shows that the fibres are inclined at varying angles to the junction line between shelly material and matrix, and that they are arranged so that the greater angles occur in the posterior portion, becoming gradually smaller toward the anterior where the fibres are more or less tangential. Punctae were not observed even in heated specimens, which process (Thomson, 1927, p. 107) renders them more easily visible in the terebratuloids.

Classification.

Of the classifications and divisions of the family Spiriferidae, none proves at present very satisfactory. Frederiks (1926) proposes a rather arbitrary system in which *Spirinella* fits into the subfamily Munellinae. Schuchert and Le Vene (1929), on the other hand, do not define subfamily limits, so that the affinities of *Spirinella* are not determined (cf. George, 1933).

Distribution and Stratigraphical Range.

All of the specimens here described were collected from the Cliftonwood locality, but the form is listed by Shearsby (1912, p. 113), from the Yass Beds at Wargeila. It is also known from the southern end of Rossi Street (sewerage trenches) and near Racecourse Trig. Station, Yass. The stratigraphical position of this horizon at Cliftonwood is given in detail by Shearsby (1912, p. 112). In the upper portion of the Yass Beds, above the *Leperditia shearsbyi* Chapman and *Rhombopteria laminosa* de Koninck horizon, a thickness of sediments, shales, sandstones, mudstones and limestones of about 170 feet occurs before the outcrop is reached. Above this *Spirinella* limestone follows a further series of sandstones and calcareous shales about 150 feet thick with a few indeterminable fossils, before the beds are overlain by the Laidlaw Series. The associated fauna is given by Shearsby (1912, p. 112).

Age.—The Yass Beds are members of a conformable series of alternating tuffs and sediments, lying stratigraphically above the Bango Beds containing *Halysites pycnoblastoides* Etheridge fil. (Shearsby, 1912, p. 110) and below the Hume Beds. Graptolites were recorded from these latter beds by Sherrard (1936, p. 142) and Sherrard and Keble (1937, p. 307). These authors conclude that "the graptolites indicate Zones 26 to 35 of the Silurian as divided by Elles and Wood (1913), which makes the beds at Silverdale equivalent to the Wenlock-Ludlow junction beds of England and to the Melbournian Series of Victoria (Chapman and Thomas, 1935; Keble and Harris, 1934)".

Thus the *Spirinella* limestone has its age restricted to a position in the Silurian intermediate between the *Halysites pycnoblastoides* horizon and the graptolite zones as given above.

Preservation and Matrix.—The shells are preserved in calcite, set in a matrix of impure tuffaceous limestone of light greyish colour, breaking with a hackly fracture. This latter adheres firmly to the shell and consequently difficulty is experienced in obtaining specimens showing the external surface ornamentation.

Previous References.

The only previous reference to this brachiopod is given by Shearsby (1912, pp. 112, 113), who lists the name *Meristina australis* (?) Dun from Cliftonwood and *Meristina* (?) *australis* Dun from Wargeila, but no description, nor figure, nor diagram was presented. However, the specimens described here correspond (according to Shearsby—verbal communication) to those intended for that name.

As well as considerable dissimilarity in internal structure, *Atrypoidea australis* (Dun) differs from *Spirinella caecistriata* in having a much shorter hinge-line, rounded outline, no areas, smoother shell, and is grouped (Schuchert and Le Vene 1929, p. 20) with the Atrypinae.

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EXPLANATION OF PLATE VII.

Spirinella caecistriata, n. sp.

1.—Dorsal view of holotype. Australian Museum No. F39376, × 2.

2, 3, 4.—Lateral, ventral and anterior marginal views respectively of same specimen, × 2.

5.—Portion of external ornamentation. Paratype. Australian Museum No. F39378, × 4 approx.

6, 7, 8, 9.—Dorsal, lateral, ventral and anterior marginal views respectively of a topotype. Australian Museum No. F39377, × 2.

10, 11.—Dorsal and ventral internal moulds. Paratype. Australian Museum No. F39379, × 2.